CAMERON

Measurement Systems

NUFLO™

Series 1000 Watercut Monitor

User Manual

Manual No. 100080001, Rev. 01

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Table of Contents

Introduction **1**

Specifications **1**

Installation **1**

Electrical Connections 4

Power Supply Configurations **5**

Two Power Supply Operation 5

Single Power Supply Operation 6

Calibration **7**

Calibration of the Crystal Controlled Oscillator 8

Analog Output Calibration 8

Spare Parts List **10**

Introduction

The NuFlo Series 1000 Watercut Monitor consists of the NuFlo Capacitance Probe and additional circuit cards. The frequency generated by the probe oscillator circuit varies according to the watercut of the emulsion flowing through the capacitance probe. This frequency, however, does not vary linearly with the watercut; the additional circuitry compensates for this non-linearity and yields a linear 4-20-mA current output signal.

NuFlo watercut monitors are CSA-certified as explosion-proof for Division 1, Class I, Group C & D hazardous locations.

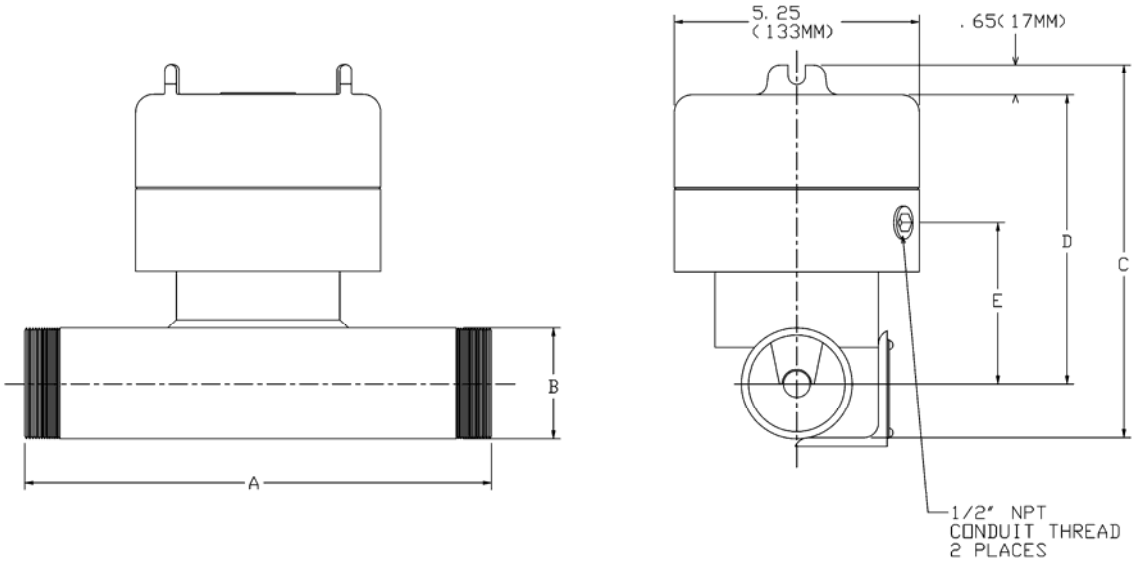
Specifications

Watercut Range	0 to 100 percent (other watercut ranges are available - consult your Cameron representative)
Input Power (terminals 3 & 4)	12 to 30 VDC at 150 mA max.
Current Loop Power (terminals 1 & 2)	24 to 30 VDC at 24 mA max. *Power is customer-supplied and must have less than 5mVac ripple.*
Output Current Operating Range	4 mA to 20 mA (adjustable)
Accuracy	±1% watercut over 0 to 50% range with homogeneous emulsion*
Pressure Rating	Varies with end connection (see pages 2 and 3)
Operating Temperature	0°F to 158°F (-17°C to 70°C)
Probe Body Material	Stainless Steel 316/316L
Probe Flange Material	Carbon Steel – ANSI B16.5, Mat'l Group 1.1

* Due to changes in the phase of oil that occur at watercuts above 50% and the inability to determine the point at which these changes will occur, the accuracy of watercut measurements above 50% cannot be predicted.)

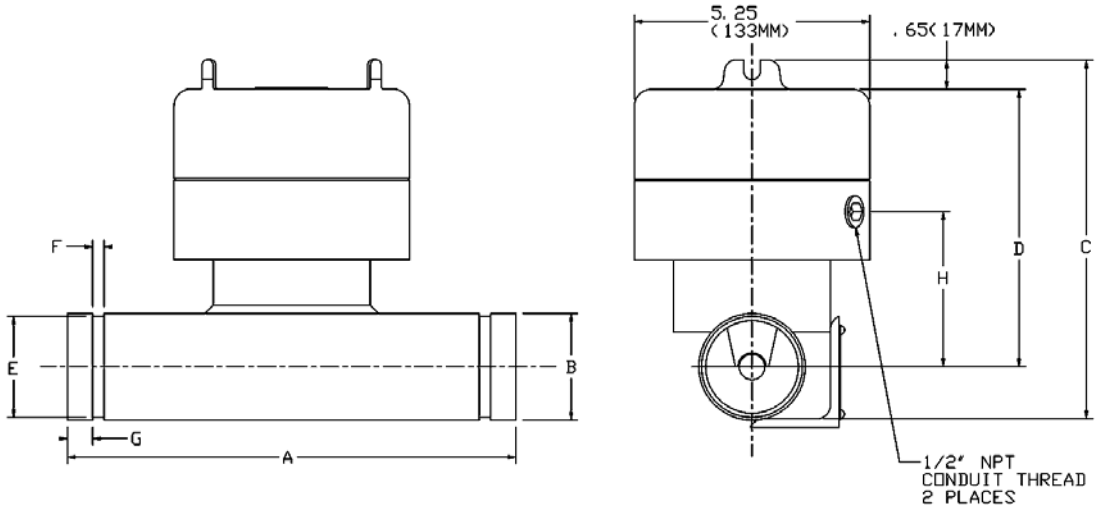
Installation

Watercut monitors must be installed vertically, with either end up. This orientation helps maintain a constant liquid fill with no trapped air. The monitor's position should allow easy access to the circuit board housing to facilitate calibration and maintenance. See pages 2 and 3 for dimensions of watercut monitors with various style and size connections.



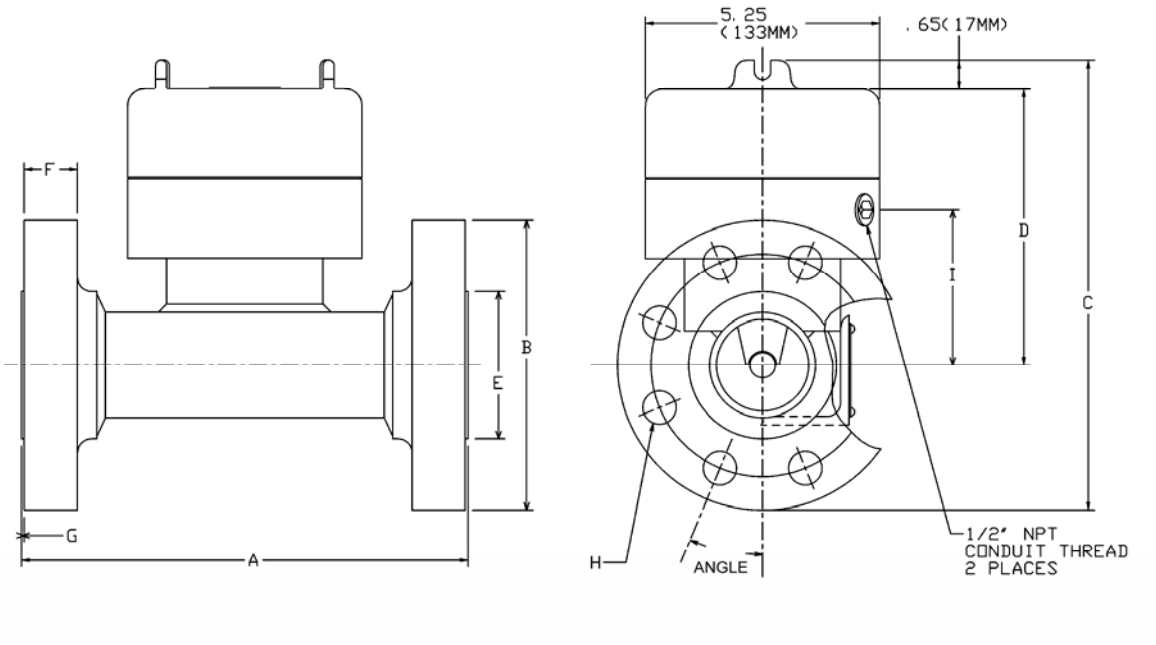
Watercut Monitor Dimensions—NPT Male Threaded Ends

Nom. Size in. (mm)	Thread Type	Max. WP psi (MPa)	Part No.	A	B	C	D	E
2 (50)	2-in. API LP	1000 (6.9 Mpa)	100079704	10.00 (254)	2.37 (60.2)	8.23 (209)	6.21 (157.7)	3.49 (88.6)



Watercut Monitor Dimensions—Victaulic Grooved Ends

Nom. Size in. (mm)	Groove Type	Max. WP psi (MPa)	Part No.	A	B	C	D	E	F	G	H
2 (50)	2-in. ES	1000 (6.9 Mpa)	100079705	10.00 (254)	2.37 (60.2)	8.23 (209)	6.21 (157.7)	2.25 (57.2)	0.255 (6.5)	0.562 (14.3)	3.49 (88.6)
3 (80)	3-in. ES	1000 (6.9 Mpa)	101002253	12.00 (304.8)	3.50 (88.9)	9.16 (232.7)	6.76 (171.7)	3.34 (84.8)	0.255 (6.5)	0.562 (14.3)	4.04 (102.6)



Watercut Monitor Dimensions—Raised-Face Carbon Steel Flanged Ends

Flange Size (ANSI)		Max. WP									H			
in. (mm)	lb	psi (MPa)	Part No.	A	B	C	D	E	F	G	Bolt Qty.	Dia.	I	Angle, °
2 (50)	150	285 (1.96)	100079706	10.00 (254)	6.00 (152.4)	9.86 (250.4)	6.21 (157.7)	3.62 (91.9)	0.69 (17.5)	0.06 (1.6)	4	3/4 (19.1)	3.49 (88.6)	45
2 (50)	300	740 (5.10)	100079707	10.00 (254)	6.50 (165.1)	10.11 (256.8)	6.21 (157.7)	3.62 (91.9)	0.81 (20.6)	0.06 (1.6)	8	3/4 (19.1)	3.49 (88.6)	22.5
2 (50)	600	1480 (10.20)	100079708	10.00 (254)	6.50 (165.1)	10.11 (256.8)	6.21 (157.7)	3.62 (91.9)	1.00 (25.4)	0.25 (6.4)	8	3/4 (19.1)	3.49 (88.6)	22.5
3 (80)	150	285 (1.96)	101002254	12.00 (304.8)	7.50 (190.5)	11.17 (283.7)	6.77 (172)	5.00 (127)	0.88 (22.4)	0.06 (1.6)	4	3/4 (19.1)	4.05 (102.9)	45
3 (80)	300	740 (5.10)	101002255	12.00 (304.8)	8.25 (209.6)	11.54 (293.1)	6.77 (172)	5.00 (127)	1.06 (26.9)	0.06 (1.6)	8	7/8 (22.2)	4.05 (102.9)	22.5
3 (80)	600	1480 (10.20)	101309649	12.00 (304.8)	8.25 (209.6)	11.54 (293.1)	6.77 (172)	5.00 (127)	1.25 (31.8)	0.25 (6.4)	8	7/8 (22.2)	4.05 (102.9)	22.5
4 (100)	150	285 (1.96)	100079709	12.00 (304.8)	9.00 (228.6)	12.42 (315.1)	7.27 (184.7)	6.19 (157.2)	0.88 (22.4)	0.06 (1.6)	8	3/4 (19.1)	4.55 (115.6)	22.5
4 (100)	300	740 (5.10)	101211166	12.00 (304.8)	10.00 (254)	12.92 (328.2)	7.27 (184.7)	6.19 (157.2)	1.19 (30.2)	0.06 (1.6)	8	7/8 (22.2)	4.55 (115.6)	22.5
4 (100)	600	1480 (10.20)	101002256	12.00 (304.8)	10.75 (273.1)	13.30 (337.8)	7.27 (184.7)	6.19 (157.2)	1.5 (38.1)	0.25 (6.4)	8	1 (25.4)	4.55 (115.6)	22.5
6 (150)	150	285 (1.96)	100079710	12.00 (304.8)	11.00 (279.4)	14.50 (368.3)	8.35 (212.1)	8.50 (215.9)	0.94 (23.9)	0.06 (1.6)	8	7/8 (22.2)	5.61 (142.5)	22.5
6 (150)	300	740 (5.10)	120125478	12.00 (304.8)	12.50 (317.5)	15.25 (387.4)	8.35 (212.1)	8.50 (215.9)	1.38 (35.1)	0.06 (1.6)	12	7/8 (22.2)	5.61 (142.5)	15
6 (150)	600	1480 (10.20)	101001289	12.00 (304.8)	14.00 (355.6)	16.00 (406.4)	8.35 (212.1)	8.50 (215.9)	1.88 (47.8)	0.25 (6.4)	12	1 1/8 (28.6)	5.61 (142.5)	15

Electrical Connections

To maintain the explosion-proof rating of this device, the electrical installation must conform to all applicable electrical code requirements. The watercut monitor must be connected to a substantial earth ground and a conduit seal must be installed within 18 in. of the instrument. The conduit seal may be purchased locally.

To connect the earth ground to the watercut monitor, perform the following steps:

1. Unscrew the circuit card housing cover.
2. Note the orientation of both circuit cards, and then carefully remove them.
3. Connect the ground using the grounding screw and wire terminal in the bottom of the card housing.
4. Reinstall the Lower Watercut Monitor circuit card (Part No. 100005135) as follows:
    a. Insert the two banana plugs on the card into the jacks in the bottom of the card housing.
    b. Insert the antenna connection screw through the center hole of the card and tighten securely.
5. Reinstall the Upper Watercut Monitor circuit card (Part No. 100005136) as follows:
    a. Insert the connecting pins on the bottom of the upper card into the socket on the lower card.
    b. Place two screws through the upper card into the lower card standoffs to attach the upper card to the lower card, and tighten securely.
6. Reinstall the housing cover.

The watercut monitor's flexible design allows it to be easily connected to its host equipment (see Figure 1). The 4-20-mA output is optically isolated from the other circuitry in order to provide a floating analog output. This mode of operation requires two power supplies that are isolated from the host system or the use of the optional isolating power supply board.

In any configuration, the load in the current loop must be placed between the "-" output terminal of the 4-20 mA output (terminal 2) and the power supply common.

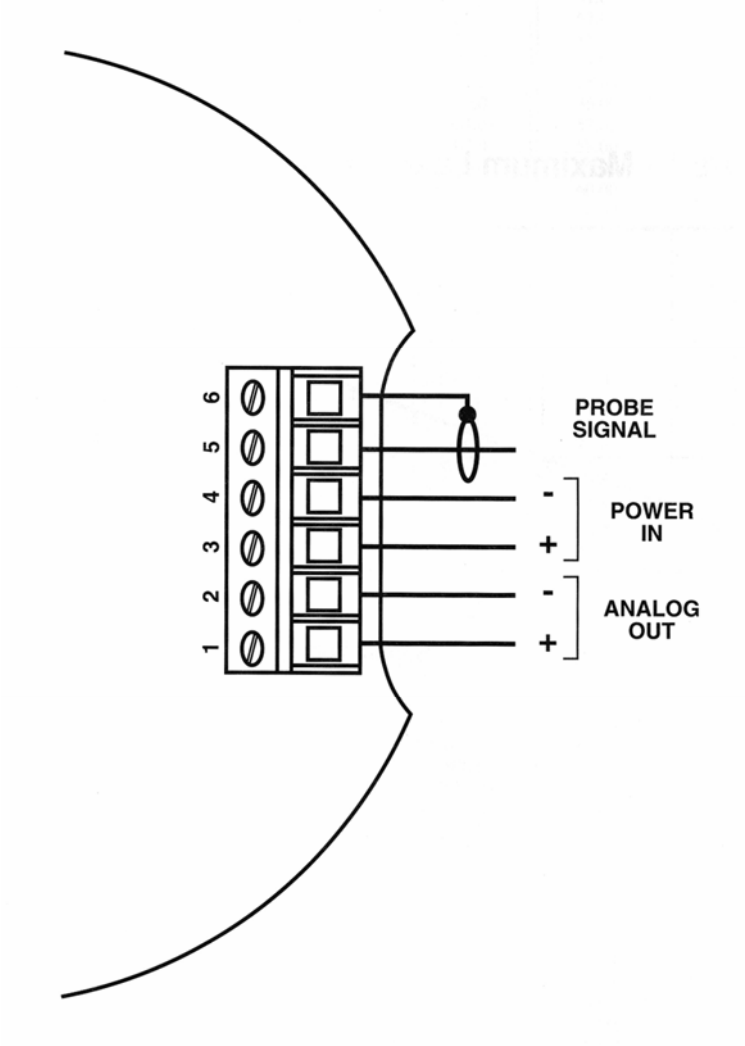


Figure 1—Electrical connections

Power Supply Configurations

Two Power Supply Operation

In this configuration, a floating analog output is possible. In the two-power supply mode of operation, the 4-20 mA is powered by one supply, while the second power supply runs the digital circuitry. Because the digital circuit ground is almost always connected to the earth ground through the body of the capacitance probe, this power supply cannot be floating.

The digital circuitry power supply must have an output of 12 to 30 Vdc. The watercut monitor should be wired as shown in Figure 2. A minimum 200-mA current capacity is recommended for this power supply. Maximum ripple should be 5 mV peak-to-peak.

The power supply for the analog output must have an output between 24 and 30 Vdc, depending on the load. Maximum ripple should by 5 mV peak-to-peak. Refer to Figure 3 for the loop voltage required.

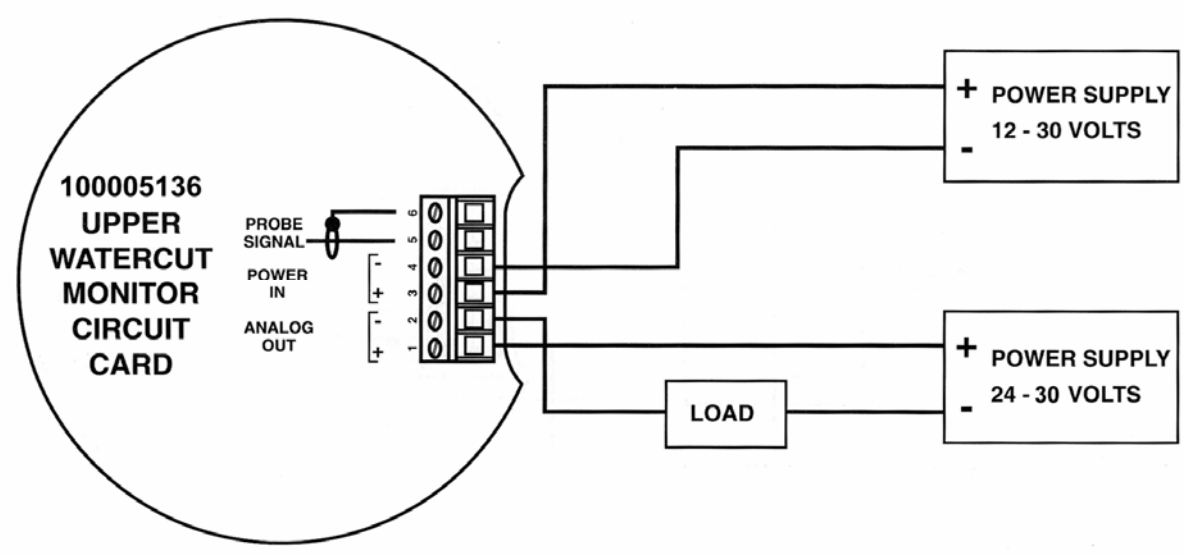


Figure 2—Two power supply configuration

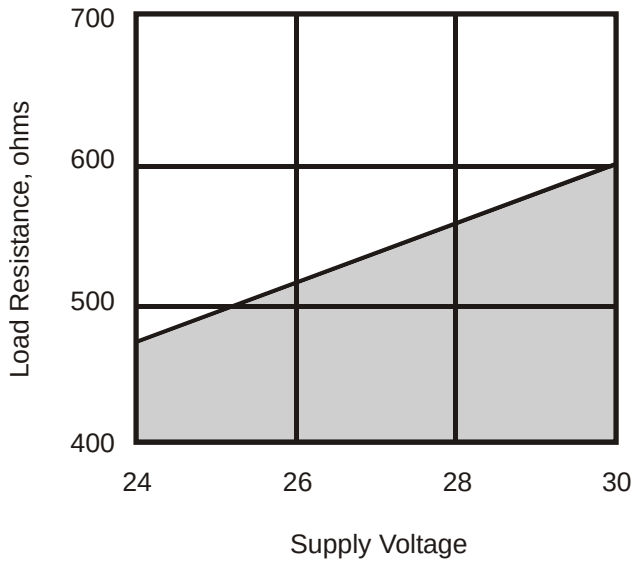


Figure 3—Maximum load resistance

Single Power Supply Operation

In this configuration, a floating analog output is not possible. The digital circuit ground, which is tied to the analog circuitry in the one-power-supply mode of operation, is connected to the earth ground through the body of the capacitance probe.

The power supply used in this mode must have an output between 24 and 30 Vdc and a current capacity of at least 200 mA. Maximum ripple should be 5 mV peak-to-peak. The watercut monitor must be wired as shown in Figure 4.

The loop voltage requirement again depends on the load, but can never exceed 30 Vdc in this configuration. Refer to Figure 3 for maximum load resistance values.

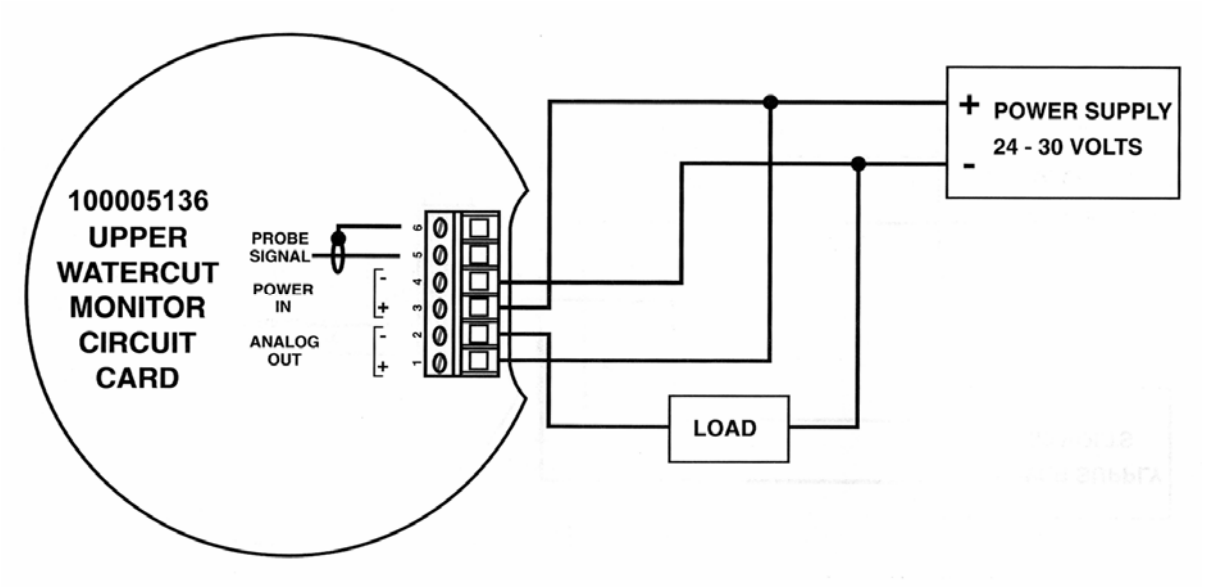


Figure 4—Single power-supply configuration

Calibration

Every NuFlo Capacitance Probe is calibrated before it leaves the factory. However, since the crude oil chemistry and fluid temperature used during the factory calibration may differ from the chemistry and temperature of fluid at the field location, adjustment of the capacitance probe is usually necessary.

For proper calibration, the probe must be completely liquid filled with no air trapped inside. The probe may be installed or removed from the flow line during calibration.

To check the calibration of a capacitance probe, perform the following steps:

1. Fill the probe with clean, dry crude oil from the location to be served. Alternately, a sample of oil with a non-zero watercut may be used if the watercut percentage is accurately known and the emulsion is homogeneous.

2. Set the probe output frequency.

   - If clean dry crude oil is used, set the probe output to 1025.000 kHz.
   - If a crude sample with a non-zero watercut is used, perform the following:

     a. Verify the exact watercut percentage.

     b. Look up the frequency that corresponds to the watercut percentage and probe size in Table 1, pages 9 and 10, and set the probe output accordingly.

3. Bring the entire assembly to the temperature it will experience in service.

Note—This step is extremely important since differences between calibration temperature and operating temperature can cause significant measurement inaccuracies.

4. Observing polarity, connect a 12- to 30-Vdc power supply to terminals 3 and 4 and check the frequency on terminals 5 and 6 with a frequency counter. Allow the unit to stabilize until the output frequency remains constant. The target frequency may be found in Table 1, pages 9 and 10.

5. If the probe frequency is not within 15 Hz of the value specified in the table, adjust the probe oscillator as follows:

    a. Unscrew the pipe plug in the trimmer capacitor access hole.

    b. Using a non-metallic tool, adjust the trimmer capacitor on the probe circuit assembly until the output frequency agrees with the table entry.

    c. Replace the pipe plug in the trimmer capacitor access hole. This is the only adjustment required to calibrate the capacitance probe.

Calibration of the Crystal Controlled Oscillator

The crystal-controlled oscillator, which controls the gate period during which probe pulses are counted, is calibrated at the factory and should not require adjustment. However, the frequency may be adjusted by a trimmer capacitor on the Lower Watercut Monitor circuit card.

For best accuracy, bring the unit to operating temperature and allow it to stabilize before adjusting the trimmer capacitor.

A hole in the Upper Watercut Monitor circuit card allows easy access to the trimmer capacitor with a small adjustment screwdriver. The trimmer cap should be adjusted until the frequency from the oscillator is 32.768 kHz, plus-minus 1 Hz. The crystal frequency may be monitored on test point T1 on the Upper Watercut Monitor circuit card.

Analog Output Calibration

The analog output is calibrated at the factory and should not require adjustment. If field adjustment is needed, note that optimum accuracy will be achieved by calibrating the unit at the temperature it will see in service.

1. Connect the watercut monitor as per Figure 2 or Figure 4, replacing the load in either case with an accurate milliammeter that reads to 0.01 mA accuracy.

2. Connect a frequency generator to terminals 5 and 6.

3. Set the output of the generator for a 0- to 2-volt square wave at 1025.000 kHz plus-minus 15 Hz.

4. Adjust the “ZERO” potentiometer on the Upper Watercut Monitor circuit card until the analog output is 4.00 mA.

5. Remove the frequency generator signal from pins 5 and 6.

6. Place a jumper across terminals 5 and 6 to short the terminals together.

7. Adjust the “SPAN” potentiometer, which is also on the Upper Watercut Monitor circuit card, until the analog output is 20.0 mA.

8. Remove the jumper from terminals 5 and 6.

9. Reapply the 1025.000 kHz signal to terminals 5 and 6.

10. Adjust the “ZERO” potentiometer for 4.00 mA loop current.

11. Remove the signal and reconnect the jumper to terminals 5 and 6.

12. Readjust the “SPAN” potentiometer until the output current is 20.0 mA.

13. Repeat Steps 8 through 12 several times if necessary until the adjustments cease to interact.

Table 1—Watercut Percentage vs. Frequency

Watercut Percent	2" Probe Frequency Hz	3" Probe Frequency Hz	4" Probe Frequency Hz	6" Probe Frequency Hz
0.0	1025000	1025000	1025000	1025000
0.1	1024890	1024908	1024966	1024930
0.2	1024780	1024816	1024932	1024860
0.3	1024670	1024724	1024898	1024790
0.4	1024560	1024632	1024864	1024720
0.5	1024450	1024540	1024830	1024646
0.6	1024334	1024445	1024740	1024572
0.7	1024218	1024350	1024650	1024494
0.8	1024102	1024255	1024560	1024416
0.9	1023986	1024160	1024470	1024338
1.0	1023870	1024065	1024380	1024260
1.1	1023754	1023970	1024290	1024182
1.2	1023638	1023875	1024200	1024104
1.3	1023522	1023780	1024110	1024026
1.4	1023406	1023685	1024020	1023948
1.5	1023290	1023590	1023930	1023870
1.6	1023170	1023491	1023838	1023788
1.7	1023050	1023392	1023746	1023736
1.8	1022930	1023293	1023654	1023684
1.9	1022810	1023194	1023562	1023572
2.0	1022690	1023095	1023470	1023460
2.5	1022090	1022600	1023010	1023049
3.0	1021475	1022090	1022530	1022630
3.5	1020860	1021580	1022050	1022207
4.0	1020225	1021055	1021555	1021770
4.5	1019590	1020530	1021060	1021330
5.0	1018935	1019990	1020550	1020875
5.5	1018280	1019450	1020040	1020417
6.0	1017610	1018890	1019515	1019915
6.5	1016940	1018330	1018990	1019414
7.0	1016250	1017760	1018445	1018965
7.5	1015560	1017190	1017900	1018520
8.0	1014850	1016600	1017340	1018020
8.5	1014140	1016010	1016780	1017519
9.0	1013415	1015405	1016210	1017010
9.5	1012690	1014800	1015640	1016499
10.0	1011950	1014175	1015050	1015970
11.0	1010445	1012915	1013850	1014895
12.0	1008900	1011625	1012620	1013790
13.0	1007325	1010300	1011360	1012655
14.0	1005730	1008945	1010065	1011490
15.0	1004120	1007560	1008745	1010295
16.0	1002470	1006140	1007400	1009070

Table 1—Watercut Percentage vs. Frequency

Watercut Percent	2" Probe Frequency Hz	3" Probe Frequency Hz	4" Probe Frequency Hz	6" Probe Frequency Hz
17.0	1000740	1004685	1006010	1007815
18.0	998960	1003120	1004570	1006530
19.0	997160	1001480	1003085	1005210
20.0	995320	999835	1001545	1003860
21.0	993435	998140	999955	1002315
22.0	991495	996395	998315	1000730
23.0	989490	994600	996620	999265
24.0	987430	992755	994880	997740
25.0	985320	990860	993090	996155
26.0	983155	988915	991245	994510
27.0	980965	986925	989355	992800
28.0	978715	984885	987415	991035
29.0	976385	982790	985420	989210
30.0	974050	980645	983380	987320
31.0	971700	978450	981270	985370
32.0	969315	976205	979085	983350
33.0	966920	973830	976850	981285
34.0	964505	971385	974560	979170
35.0	962070	968850	972215	977000
36.0	959620	966270	969820	974800
37.0	957155	963745	967370	972555
38.0	954675	961180	964865	970260
39.0	952175	958585	962310	967920
40.0	949660	955950	959700	965530
41.0	947130	953305	957035	963090
42.0	944580	950600	954315	960605
43.0	942015	947830	951545	958070
44.0	939435	945055	948720	955485
45.0	936840	942245	945840	952850
46.0	934290	939395	942910	950165
47.0	931695	936510	939980	947430
48.0	929025	933635	937155	944650
49.0	926395	930845	934420	941895
50.0	923810	928085	931710	939245

Spare Parts List

The following spare parts are recommended for the Series 1000 Watercut Monitor:

Quantity	Part Number	Description
1	100005135*	Circuit Assembly – Lower Watercut Monitor Board
1	100005136	Circuit Assembly – Upper Watercut Monitor Board
1	100015379	Antenna O-ring

* Specify probe size and watercut range.

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